Development of E-Module Based on Problem Based Learning (PBL) on Heat and Temperature to Improve Student's Science Process Skill

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ABSTRACT
The purpose of the developing research of a Problem Based Learning (PBL) e-module is to improve student's science process skills. This research method used research and development (R&D) with a 4D model (Define, Design, Development, and Disseminate). This product was made by using *I-Spring Suite 8.0* application. This product was tested on 210 students of class XI Science at Public High School 13 Bekasi, Indonesia on heat and temperature topic. The results of this e-module validation by material experts were 84.06% (very feasible), media experts 93% (very feasible), and learning experts 89% (very feasible). Instrument for improving science process skills used validity testing with product moment and reliability testing with alpha cronbach. To measure the improvement of science process skill is used N-Gain which measure the science process skill between before and after learning on heat and temperature topic. The n-gain score is 0.51 (moderate category). So, development of e-module based on Problem Based Learning (PBL) on heat and temperature topic could improve student's science process skill.
KEYWORDS: e-module, Problem Based Learning, Science Process Skill

1. INTRODUCTION

A process that can motivate students to learn from real problems is needed in scientific learning. These problems are often related to knowledge that has been learned or is still being learned and exists in everyday life. According to research conducted by Serevina (Serevina, 2017), experiential-based learning strategies are an example of a scientific approach that can improve high school student learning outcomes. Another learning model that uses a scientific approach is Problem Based Learning (PBL). The model that is suitable for the development of 21st century students is PBL because the learning model uses a problem or situation as a starting point for learning and seeking information (Dwyer, 2014).

PBL learning encourages students to solve problems and build their own knowledge through learning activities, focus on the material being studied, carry out scientific activities and communicate with group work, and use environmental information resources, libraries, and the Internet (Thobroni, 2016). Usually students seek, analyze, synthesize and apply information, under the guidance of the teacher, to solve the problems presented at the beginning (Hujiser, 2015). Problem solving based e-modules can encourage students by providing concrete experiences to solve problems independently and train higher order thinking (Suarsana, 2013).

The characteristics of PBL as a constructivist learning method oriented to student centered learning are capable of fostering a creative, collaborative spirit, metacognitive thinking, developing higher-order thinking skills, increasing understanding of meaning, increasing independence, facilitating problem solving, and building

teamwork (Sofyan, 2016). The problem based learning model is a learning model that stimulates students to think about solving contextual problems (Mariani, 2014).

Through the Problem Based Learning model, students construct knowledge by building reasoning so that they are expected to be able to solve problems with various alternative solutions and identify existing problems (Sudarman, 2007). The Problem Based Learning learning model is effective for improving student's science process skill (Hardiyanti, 2017). Scientists use science process skill or cognitive skill as a systematic approach to solving problems (Kurniati, 2001).

The self directed learning technique can be used by teachers to encourage their students to learn in an independent way both inside and outside the classroom. Based on the results of a needs analysis conducted on 210 class XI Science students at Public High School 13 Bekasi, Indonesia, 85.6% of students needed e-modules as a source of self regulated learning, 78% of students lacked information regarding temperature and heat, 55% had heard of Problem Based Learning (PBL), 75% of students have never used e-modules, and 95% of students stated that research on the Development of E-Module Based on PBL on Heat and Temperature topic is required for research.

From the problems that have been described, it shows that a medium or learning material is needed that can be used in the learning process as student independent learning materials to support understanding the concepts of temperature and heat. One form of independent learning source is a module (Tania, 2017). Until now, modules consist of two categories, namely printed modules and digital modules. Modules that are digital have the advantage of displaying some material using interactive learning media (Irwandani, 2017).

Interactive learning media makes it easier for educators to teach abstract material (Irwandani, 2017). Several interactive learning media are considered capable of explaining phenomena that occur in nature and presenting them in the classroom (Wulandari, 2016). It is necessary to develop learning source in the form of digital modules which will later be suitable for physics learning on temperature and heat material because there are pictures, text, videos, and experiments so that learning is not monotonous and can motivate students to be interested and enthusiastic in learning physics.

In the preliminary study, previously there was research on the development of e-modules conducted by Agustina (Agustina, 2015) showing that the e-modules developed met valid and effective criteria to facilitate independent learning and provide structured learning source for students.

According to research conducted by Hardiyanti (Hardiyanti, 2017) shows that the Problem Based Learning (PBL) model is effective for improving students' science process skills. This is indicated by the improvement of the science process skills of the experimental class which applies the PBL model better than the control class which applies conventional learning with lecture and discussion methods. Then research conducted by Sofyan (Sofyan, 2016) PBL has the potential to be applied in the implementation of the 2013 Curriculum in Vocational Schools. There is suitability in the implementation of learning in the application of the 2013 Curriculum. Based on preliminary studies, it can be formulated that PBL based e-modules on temperature and heat material can be used as one of the independent learning source in physics learning.

2. RESEARCH METHOD

This study used research and development methods with considerations in accordance with the objectives of this study, namely to produce a product in the form of a physics e-module based on PBL. The method used is 4D (Define, Design, Develop, and Disseminate) formulated by Thiagarajan (Thiagarajan, 1974). This research consists of four stages, namely Defining, Designing Instrument, Development, and Dissemination. In general, the research stages can be described as follows:

2.1. Stage Define : Defining of E-Module

In the first stage analyze the needs of e-module development and identify e-module feasibility. The development of the e-module is preceded by the formulation of the problem to find out the basic problems encountered in the learning process including background, student needs, learning environment, science and technology, student cognitive, selection of teaching materials, etc.

2.2. Stage Design: Designing of E-Module

This stage aims to design and plan the concept of the e-module to be developed. The design of the e-module developed is systematic and conceptual by analyzing the learning objectives at the beginning. In the initial design the module was designed according to the e-module component which consisted of learning

objectives, mind mapping, material descriptions, pictures, sample questions, and evaluation questions.

2.3. Stage Develop: Development of E-Module

In this third stage, the realization of the e-module design that has been prepared at the design stage is carried out. The activities carried out at this stage are validation tests by experts (material experts, media experts, and learning experts) to determine the validity of the product.

2.4. Stage Disseminate: Disseminate of E-Module

The results of the revised e-module realization after the validation test will be disseminated. The desiminate stage is an effort to spread the e-module in real situations in the classroom.

3. E-MODULE BASED ON PROBLEM BASED LEARNING (PBL)

E-Module based on PBL is digital learning source that covered PBL stages in a systematic and interesting manner which can be accessed anywhere and anytime independently by students according to the expected learning objectives. The stages of the PBL module according to Agustina (Agustina, 2015) related to teacher and student activities in the learning process are as follows:

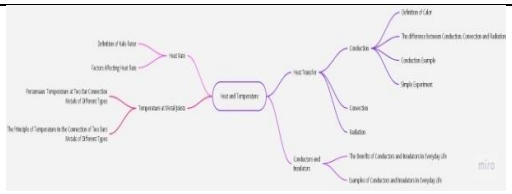
Table 3.1. Stages of PBL

Stage of Learning	Teacher Behavior
Stage 1: Provide problem orientation to students.	According to Sugiyanto (Sugiyanto, 2010) argues that the teacher gives orientation about the problem to students. The teacher presents problems, discusses learning objectives, explains learning needs, and motivates students to engage in selected problem solving activities.
Stage 2: Organize students to carry out investigations.	The teacher helps students to define and organize learning tasks related to problem solving.
Stage 3: Assist in independent and group investigations.	The teacher encourages students to obtain appropriate information, conduct investigations, and seek explanations and solutions.
Stage 4: Develop and present work results.	The teacher helps students to develop and present relevant work results in reports.
Stage 5: Analyze and evaluate the problem solving process.	The teacher encourages students to evaluate investigations and provides clarification of the issues that have been discussed, and concludes with students.

(Source: Agustina, 2015)

E-Module was developed using the I-Spring suite 8.0 application. This application is an animation program that converts presentation files into flash format which contains animations, images, videos, and audio so that they can help students independently (Rahmah, 2017). The features contained in I-Spring suite 8.0 are more complete than the previous version so that they support the development of interesting and more interactive teaching materials along with various forms of quizzes that are easy for students to understand and have a good impact on reducing student misconceptions (Nurdiansyah, 2017). The following is a display of the Problem Based Learning E-module:

Tabel 3.2 Display of Physics E-Module in Learning Activities

Views of E-Module	Information
	
Mind Mapping of E-Module	ind Mapping of the learning process

 Stage 1: Problems	Stage 1 *Problem Based Learning* (PBL) There is a presentation of problems to students related to real life to get information and provide hypotheses.
 Stage 2: Learning	Stage 2 *Problem Based Learning* (PBL). There is a description of temperature and heat material and examples of its application in everyday life are also presented.
 Stage 3: Inquiry	Stage 3 *Problem Based Learning* (PBL). There are investigative activities, namely carrying out simple experiments related to the concepts of temperature and heat.
 Stage 4: Development of Result	Stage 4 *Problem Based Learning* (PBL). There is a presentation and explanation of examples of the application of the concepts of temperature and heat in real life accompanied by pictures, brief information, and discussion questions.
 Stage 5: Analysis and Evaluation Solution to problem	Stage 5 *Problem Based Learning* (PBL). There is proof of whether the hypothesis is correct or not accompanied by a description.

(Source: own source)

4. DATA ANALYSIS TECHNIQUE

The information or data collected is selected and grouped based on the assessment instrument category.

4.1. Material expert validation instrument, media, learning teachers and students

The authentic assessment of the questionnaire given refers to the assessment of the technical criteria for data analysis used based on benchmarks for assessment and conversion in the form of a scale. The conversion score on the scale determines the level of validity. The scale used is as below:

Table 4.1 The Scale Assessment of material experts, media experts, learning experts, teacher and students

No.	Answers	Score
1.	Very good	4
2.	Good	3
3.	Enough	2
4.	Not Good	1

(Source: Sugiyono, 2013)

The data obtained then calculated the percentage of the score as follows:

$$Percentage\ Score = \frac{\sum Gained\ Score}{\sum Maximum\ Score} \times 100\%$$

The score is obtained and measured using a score interpretation for the Likert scale, as follows:

Table 4.2 Interpretation of Likert Scale

Percentage	Interpretation
0% - 25%	Very unfeasible
26% - 50%	Unfeasible
51% - 75%	Feasible
76% - 100%	Very Feasible

(Source: Sugiyono, 2013)

4.2. Science Process Skill Instrument

The science process skills instrument is measured by using a science process skills written test. The data obtained from the written test as follows:

a. Score

The score of each student is determined by calculating the correct answers. The scoring method is based on the right only method, namely the correct answer is given a score of one and the wrong answer or item not answered is given a score of zero. Scoring is calculated using the following conditions (Munaf, 2001):

$$S = \sum R \quad \text{.....eq.1}$$

Score = number of correct answers
R = The correct student answers

b. Determining the gain value

Gain is the difference between the initial test score and the final test score. The gain value can be determined by the following formula:

$$G = S_f - S_i \text{.....eq.2}$$

G = gain
S_f = posttest score
S_i = pretest score

c. Determining the normalized gain value

Normalized gains are a comparison between the actual gain scores obtained by students with the maximum gain scores that are the highest gain scores that students might gain (Hake, 1997). To calculate the normalized gain value and classification it will be used equation as follows:

The normalized gains of each student (g) are defined as:

$$g = \frac{\%S_f - \%S_i}{100 - \%S_i} \text{.....eq.3}$$

g = the gain is normalized
S_f = score posttest
S_i = score pretest

The normalized gain average (<g>) is formulated as follows:

$$< g >= \frac{\%<S_f>- \%<S_i>}{(100-\%<S_i>)} \text{.....eq.4}$$

(g) = normalized gain average
(S_f) = the average score posttest
(S_i) = the average score pretest

The obtained <g> values are interpreted in accordance with Hake (1997) as in Table 4.3 below:

Table 4.3 Interpretation of Normalized Gain Values

Normalized Gain	**terpretation(Category)**
0,00 <$g \leq$ 0,30	Low
0,30 <$g \leq$ 0,70	Moderate
0,70 <$g \leq$1,00	High

(Source: Hake, 1997)

5. FINDING AND DISCUSSION

E-Module developed follows the Problem Based Learning (PBL) syntax which includes material on heat and temperature topic supplemented by text, images, mind mapping, simple experiments, and evaluation questions. The research was conducted at Public High School 13 Bekasi City, Indonesia.

Figure 5 Location of the research at Public High School 13 Bekasi City, Indonesia

In the research that has been done, it is obtained the research data in the form of validity tests and trials to analyze the validity of the developed of physics e-module based on PBL. The developed of physics e-module based on PBL has been validated by experts (material experts, media experts, and learning experts). From the results of validation by media experts, material experts and learning experts as well as e-module trials to teacher and students, it can be stated that the e-modules developed are feasible for use in learning. The results of validation by material experts are as follows:

Table 5.1 Validation of Material Experts

No	Measured Aspects	Percentage	Interpretation
1	Appropriateness	85.5%	Very good
2	Module Characteristics	84%	Very good
3	Presentation Techniques	84.25%	Very good
4	Material Language	82.0%	Very good
	Average score	84.06%	Very good

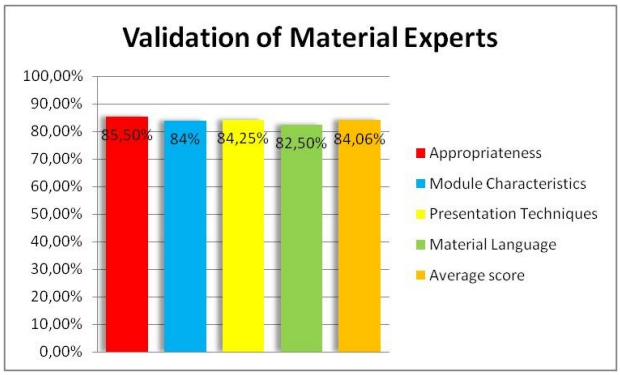


Figure 5.1 Histogram of Validation by Material Experts

From the histogram of e-module validation results by material experts, an average value of 84.06% was obtained. Based on the interpretation of the Likert scale, it can be categorized "very feasible " category. Furthermore, the assessment instrument is carried out by media experts. The results of validation by media experts are as follows:

Table 5.2 Validation of Media Experts

No	Measured Aspects	Percentage	Interpretation
1	Cover View	95%	Very good
2	Accuracy	90%	Very good
3	Font Display	93%	Very good
4	Display graphs/images/tables	94%	Very good
	Average score	93%	Very good

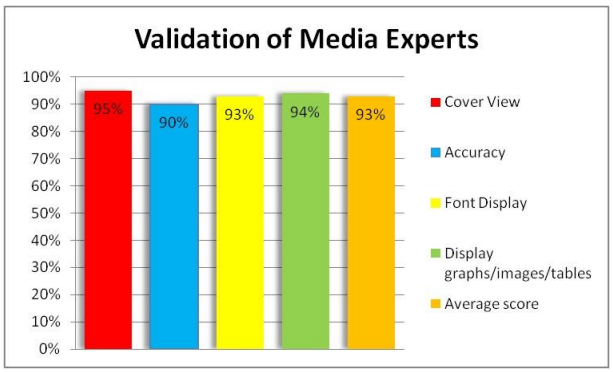


Figure 5.2 Histogram of Validation by Media Experts

The histogram of the results of the e-module validation test by media experts showed that the average value was obtained at 93%. So, based on the Likert scale interpretation it can be interpreted that the e-module developed is "very feasible" to be used as independent learning source. Further validation by learning experts by looking at aspects of the stages of the Problem Based Learning (PBL) model includes problem orientation, organizing students to conduct investigations, assisting in independent and group investigations, developing and presenting results, and analyzing and evaluating problems. Following are the results of validation by learning experts:

Table 5.3 Validation of Learning Experts

No	Measured Aspects	Percentage	Interpretation
1	Learning Organization	88%	Very good
2	Problem Solving	90%	Very good
3	Analysis and Evaluation	86%	Very good
4	Experiment	92%	Very good
	Average score	89%	Very good

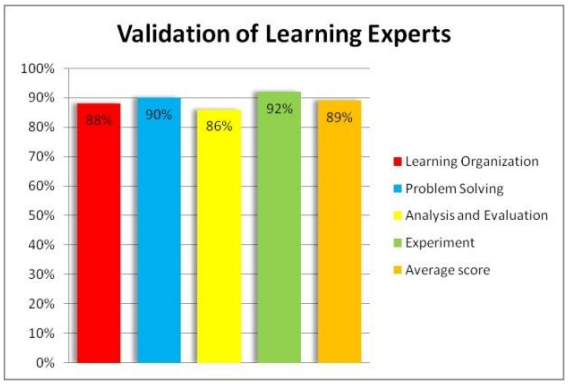


Figure 5.3 Histogram of Validation by Learning Experts

From the histogram of e-module validation results by learning experts, an average value of 89% is obtained. Based on the interpretation of validity, it can be categorized "very feasible". After validation tests were carried out by learning experts, the next research stage was e-module trials by teacher and students. The results of the e-module trial by teacher obtained the following data:

Table 5.4 E-module Trial Results by Teachers

No	Measured Aspects	Percentage	Interpretation
1	Completeness of Module Contents	90%	Very good
2	Exploration	78%	Very good
3	Elaboration	90%	Very good
4	Atractiveness	88%	Very good
5	Efektiveness	85%	Very good
6	Languange	80%	Very good
	Average score	85.17%	Very good

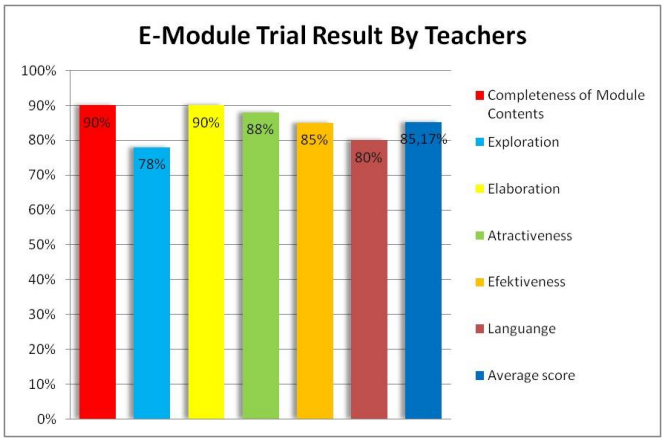


Figure 5.4 Histogram of Trial Result by Teacher

From the histogram of the e-module trials conducted by teacher, an average percentage of 85.17 was obtained. Based on the interpretation of the Likert scale, it can be categorized "very feasible". After considering the results of validation tests and product trials, a large-scale test was carried out to find out whether the e-module could improve student's science process skills through pretest and posttest instruments given to 210 class XI Science students at Public High School 13 Bekasi City, Indonesia. Prior to use, the scientific process skills instrument was tested for validity by using product moment and reliability by using Cronbach's Alpha.

The large-scale trial was conducted at Public High School 13 Bekasi City, Indonesia which consisted of 6 classes with 35 students each class. Total sample were 210 students. Large-scale trials were carried out by giving students pretest and posttest of science process skills instrument.

Based on the results of the calculation of the data obtained the average pretest score for all samples was 61.25 with the highest score 70 and the lowest score 55. Meanwhile, the posttest average score for all samples was 81.17 with the highest score 85 and the lowest score 75 to determine skill improvement student's science process can be calculated using the N-Gain test.

Table 5.5 Score of Student's Science Process Skill Pretest

No	Measured Aspects	Score	Interpretation
1	Skill Observing	60	Good
2	Skill Classifying	65	Good
3	Skill Inferencing	70	Good
4	Skill Predicting	55	Good
5	Skill Measuring	60	Good
6	Skill Communicating	64	Good
7	Skill Interpreting Data	57	Good
8	Skill Making Operational Definition	60	Good
9	Skill Forming Questions and Hypotheses	58	Good
10	Skill Experimanting	70	Good
11	Skill Formulating Model	60	Good
12	Skill Valuing	56	Good
	Average score	61.25	Good

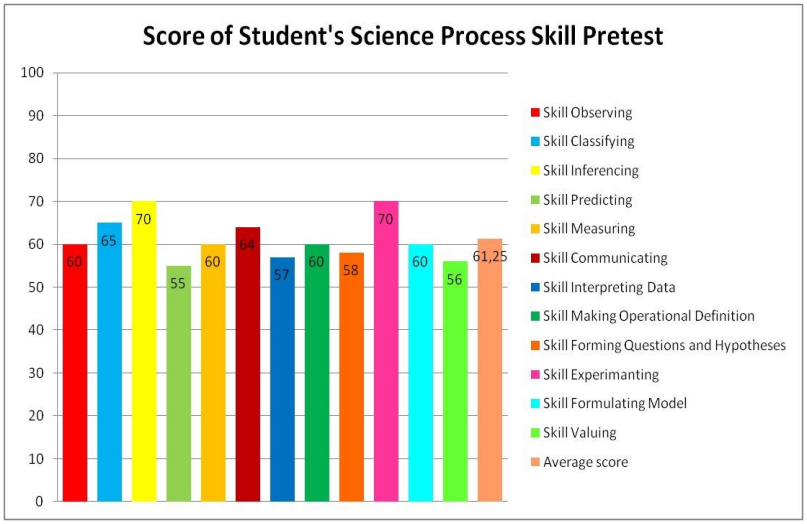


Figure 5.5 Histogram of Student's Science Process Skill Pretest

Table 5.6 Score of Student's Science Process Skill Posttest

No	Measured Aspects	Score	Interpretation
1	Skill Observing	80	Very good
2	Skill Classifying	85	Very good
3	Skill Inferencing	85	Very good
4	Skill Predicting	82	Very good
5	Skill Measuring	79	Very good
6	Skill Communicating	84	Very good
7	Skill Interpreting Data	80	Very good
8	Skill Making Operational Definition	85	Very good
9	Skill Forming Questions and Hypotheses	80	Very good
10	Skill Experimanting	81	Very good
11	Skill Formulating Model	78	Very good
12	Skill Valuing	75	Very good
	Average score	81.17	Very good

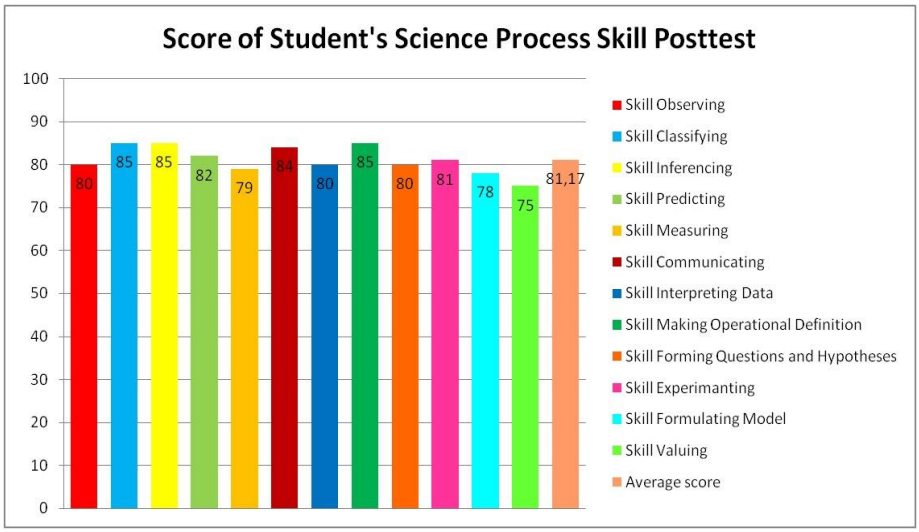


Figure 5.6 Histogram of Student's Science Process Skill Posttest

Table 5.7 The Result of N-Gain Test for Student's Science Process Skill

Class	*n*	Average score			Interpretation
		Pretest	Posttest	N-Gain	
Science Process Skill	210	61.25	81.17	0.51	Moderate

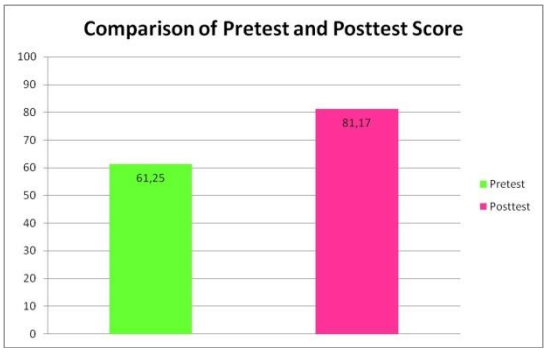


Figure 5.7 Histogram of Comparison Pretest and Posttest

Based on the data and the calculation results of the N-Gain score of 0.51 is obtained, which indicates that the score is in the "moderate" category. So, it can be concluded that the developed e-module based on PBL can improve students' science process skills.

CONCLUSION

Based on the results of this research that has been done, it can be concluded that the E-module based on Problem Based Learning (PBL) was feasible as learning source on heat and temperature topic and could improve student's science process skills. Based on the results of validation tests by material experts showed 84.06% (very feasible), media experts at 93% (very feasible), and learning experts showed 89% (very feasible). While the results of the e-module trials by teacher amounted to 85.17% (very feasible) and students obtained pretest results of 61.25 and posttest results of 81.17 indicating that this e-module could improve student's science process skills, as evidenced by the results n-gain test calculation 0.51 with moderate category.

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